AIR COMMAND AND STAFF COLLEGE

AIR UNIVERSITY

ADAPTIVE ACQUISITIONS

MAINTAINING MILITARY DOMINANCE

BY MANAGING INNOVATION

by

Robert L. Odom, Major, USAF

A Research Report Submitted to the Faculty

In Partial Fulfillment of the Graduation Requirements

Advisor: Lieutenant Colonel Thomas I. Savoie

Maxwell Air Force Base, Alabama

April 2014

Disclaimer

Abstract

Military acquisitions leaders are responsible for technology development in pursuit of innovative warfighting capabilities. Some of these innovations improve performance along existing value metrics that are used to quantify performance within the current operational models. Other innovations dramatically change both the value metrics and the operational models. Innovations of the second type are called disruptive innovations and they must be adopted by a dominant military if it is to remain in the leadership position.

Biases within dominant militaries hinder the development and adoption of these disruptive innovations. Uncertainty about future threats leads commanders to extrapolate their current capability needs into the future, which in turn focuses research and development investments into improvements along the existing value metrics. Disruptive innovations appear risky in this environment of uncertainty, and the competition for resources pushes investments toward sustaining improvements in current performance parameters, which are perceived as a safer bets.

It is the objective of this research paper to provide a framework for how acquisitions leaders can overcome these biases against disruptive innovations. Many academic research efforts have investigated the effects of innovation on business enterprises. This study proposes extending those business focused research conclusions into the military acquisitions enterprise. The concluding recommendations of this study are organizationally non-specific, so that leaders may apply the concepts in ways that make sense to their stakeholder organizations.

Introduction

The German invasion of Luxembourg, Belgium, and Holland commenced on May 10, 1940 at 4:35AM. France and Britain had prepared for a repeat of the Schlieffen Plan from World War I (WWI) and expected a slow advance of infantry. The Germans' plan to advance through the Ardennes was unexpected, and the speed of their advance was the most surprising observation.[1] They were employing of a new style of warfare, one that increased the speed of maneuver, and used Panzer tank divisions that were coordinated with tactical airpower. The orientation of this doctrine was extremely offensive in nature, and became known as Blitzkrieg. With this innovative doctrine Germany was able to annihilate France in about a month, where previously they had failed to do the same during four years of WWI.

An ironic fact about this defeat is that the British and French armies were familiar with Blitzkrieg style warfare, as well as tank and aircraft technologies that supported it. In the 1930s the British Army, the first army to use tanks, created the Experimental Mechanized Force. They conducted maneuver warfare exercises similar to Blitzkrieg with this experimental army. In the same decade in France, Charles de Gaulle proposed an army of highly mobile "shock troops", supported with armor and airpower.[2] Both nations rejected this innovative doctrine however, because its offensive approach was not consistent with their defensive paradigms.

Germany on the other hand, embraced the doctrinal shift to combined arms and maneuver warfare just as France and Britain were rejecting it. Germany was an emerging power, having been previously disarmed following its defeat in WWI. From its perspective the status quo order was unacceptable, and an offensive minded doctrine fit very well with its national ambitions. Also, German leadership was building a force from nearly nothing in the interwar years, and was

unencumbered by entrenched biases against change. Germany's expansionist ambitions allowed it to see the value in Blitzkrieg early on, when France and Britain did not.

The preceding account of the adoption of Blitzkrieg warfare in World War II (WWII) raises many questions that are relevant to today's force development decisions. First, why would leading powers fail to adopt innovations that could be decisive in the future? Second, why do they discount the value of certain innovations in the hands of competitors? Finally, are there any lessons that leaders can take away from others' failures to innovate? These are important questions that will be addressed in this study, and the answers lay in the resolution of an innovation dilemma.[3]

Military acquisitions leaders face a dilemma in their dual mandate with respect to technology development. They are responsible for improving existing capabilities that are valued by military commanders, as well as developing new capabilities enabled by innovations in technology. The dilemma is that the existing operational model is built on old value metrics, or performance parameters, and new technology may require seemingly risky changes to this value construct. Therefore, some potentially important innovations may be rejected based on perceptions of risk in the old operational model.

Experts in the field of innovation have shown that organizations must be willing to evolve their business models if they want to survive and lead in the future.[4] The military is not exempt from this reality. It must also be adaptive. Acquisitions leadership must develop technologies that improve performance along the old value metrics of an entrenched operational model, while simultaneously seeking innovations that are disruptive to this order.

The Nature of Innovation

Harvard Business School Professor Clayton Christensen has identified two main classes of innovations. He defines membership in these classes based on the innovation's impact on a value construct.[5] The first class he defines is sustaining innovation. These innovations improve product performance along existing value metrics, and support the current business model. Sustaining innovations are typically developed by the leaders in an industry, since they are interested in maintaining the status quo. The second class is disruptive innovation. These innovations change the value metrics, typically underperforming old technology along existing value metrics, but outperforming them on the new metrics they introduce. When these new value metrics become more important to customers than the old ones, disruption has occurred. The military also has customers with established value metrics; therefore, the labels of sustaining and disruptive also apply to military innovations.

Military value is assigned to weapon systems based on certain metrics that define the capabilities of the system. These metrics are documented during the system development and are called key performance parameters (KPPs). For example, three of the original F-18A Hornet KPPs were as follows:

1. Transonic Acceleration, 0.8 – 1.6 Mach within 120 seconds
2. Operating Radius Range, 400 nautical miles
3. Gross Takeoff Weight, no greater than 30,000 pounds.[6]

Any new innovation which improves performance primarily along existing KPPs would be considered sustaining, while an innovation that changes the value equation by adding new KPPs, and reducing the importance of old ones, is disruptive. Consider a hypothetical engine innovation developed for the F-18A that would increase thrust, reduce specific fuel consumption,

and reduce engine weight. This innovation would improve performance of the F-18, and other fighters of the same generation along the three KPPs given previously. That is, the engine innovation would not add, subtract, or change the relative importance of the KPPs. It would sustain the existing means of calculating value. Therefore, the engine innovation would be sustaining, not disruptive.

An example of disruptive innovation in fighter aircraft is stealth technology. The genesis of the first stealth fighter, the F-117 Nighthawk, came when a Lockheed Martin engineer happened to read an openly published paper by Pyotr Ufimtsev, a Soviet scientist. This paper explained the mathematical process for calculating the radar return of grouped triangular surfaces.[7] The computer limitations of that time forced the design of a diamond shaped aircraft comprised of numerous triangular surfaces. The design was very poor from an aerodynamics, stability, and control standpoint. Therefore, the performance of the F-117 was inferior along many old metrics. It was relatively slow, non-agile, had limited weapons capacity, and many other inferiorities along previously valued metrics of performance. These concerns were proven irrelevant however, since the new KPP that the F-117 introduced, its small radar cross section (RCS), completely changed the value paradigm in fighters. Improving computer technology in the 1980s enabled calculation of smooth surface RCS. This improved stealth fighter aerodynamics, stability, and control. Because of these improvements the next generation stealth fighter, the F-22 Raptor, was able to regain most of the performance that the F-117 had lost along the old fighter value metrics, while also providing value along the new value parameter of reduced RCS.

The Impact of Disruptive Innovations

Disruptive innovations can have negative impacts on stakeholders of the old value system, unless they adapt to survive in the new value paradigm. Professor Christensen stated that he has only ever found one business market leader that effectively adapted to disruptive innovations, International Business Machines (IBM), and they did it by reinventing themselves.[8] Most enterprises fail to adapt to disruptive innovation, and the repercussions of that failure is a fall from leadership, or possibly even complete collapse. One example of a failure to adapt comes from the steel industry.[9]

Throughout most of the 20th century big integrated steel mills were the market leading producers, but by the 1990s these integrated mills were shutting down due to innovations in recycling technology. Recycled steel mills, what the industry calls minimills, first appeared in the 1960s. Like any market, steel customers had quality requirements and looked for the lowest cost. However, when all suppliers were integrated mills with similar cost structures, the competition essentially boiled down to quality, since producers all charged about the same. The old value metrics were based almost entirely on quality. Minimills changed that equation, and effectively reintroduced price into the value calculus of the customer. That is what made minimills a disruptive innovation in steel. Their reduced production costs allowed them to charge so much less than integrated mills that were competitive, despite the lower quality of their steel.

It took time for the disruptive innovation in minimill steel to overtake the old technology market leaders. At first minimills were only competitive in the rebar market where quality standards were low. This competition caused integrated steel to exit the rebar market, because of reducing profits. The integrated steel executives saw rebar as a market they wanted out of anyway, and were happy to redirect those production resources into more profitable structural

steel, and sheet steel products. In time, recycling technology improved enough that minimill steel quality satisfied the structural steel market. Naturally, the prices of structural steel dropped because minimills could charge less, and integrated steel retreated up market to producing only sheet steel. The same cycle repeated a third time once minimill quality satisfied the sheet steel customers' demands, and without a higher margin market to retreat to, the integrated steel companies began to fail wholesale. According to Christensen the dynamics seen in this example apply to the military as well.[10]

There are important military analogies to the business example in steel. After hearing the same steel industry disruptive innovation story, the former Chairman of the Joint Chiefs of Staff (CJCS), General Shelton, stated that he and the other joint chiefs were the integrated steel executives, Russia was the sheet steel market, and terrorism was the rebar market.[11] In other words, he was saying that the United States military was built for competing on quality, like the integrated steel mills. He recognized that unconventional forces such as terrorists, or other non-state actors, may be a disruptive threat. General Shelton recognized that the United States military operational model and structure would require changes in order to compete effectively, especially if value metrics were shifting toward irregular warfare.

The Effect of Uncertainty on Valuing Innovations

An innovation's anticipated value is based on its expected contributions to solving both current and future military problems. This anticipated value is different than the innovation's actual value, which can't be known *a priori*. Since current problems are generally well understood, an innovation's anticipated value to solving them can be assessed fairly accurately. An innovation's value to solving future problems is more difficult to assess, since the assumptions being made about the nature of those problems may be wrong. The uncertainty in

the nature of future problems is typically handled by extrapolating today's issues into the future. For example, it may be assumed that low RCS will be valuable for fighters thirty years in the future, because it is important today. Of course it is actually impossible to know whether this will be true, but it is more likely to be true in the near future than in the far future. An additional complication is that with technology change accelerating, the "far future" becomes ever nearer.

Accelerating innovations limit how far into the future today's problems can be assumed to apply. If it were previously possible to extrapolate accurately fifteen or twenty years into the future, acceleration of innovation could bring this limit closer. In effect, the "far future" could hypothetically become as near as five or ten years ahead. This means that predicted future capability needs, which get translated into weapon system requirements, are more likely to be wrong in accelerating times. This is particularly true in light of the increasing developmental times for modern weapons; therefore, it is becoming more likely that the technology in long-lead weapon systems will be obsolete upon reaching initial operational capability (IOC). The difficulty with forecasts goes beyond technology obsolescence; there are also changes to the threat context.

Uncertainty about the future threat creates a disparity between the anticipated capability needs and the reality discovered in the future. A case in point is the F-22 Raptor in the first decade of the 21st century. Upon reaching IOC in 2005, the F-22 filled an anticipated need that did not materialize to the level expected when the program started in the early 1980s. The capabilities that the F-22 provided were intended for use against near-peer military threats such as the Soviet Union. The anticipated value of this weapon system was very high based on projecting forward the military problems of the 1980s. Certainly these early planners weren't envisioning the fall of the Soviet Union, the lack of any peer threat, and the rise of terrorism as

the most active threat to the United States into the 21st century. Because of this context change, the value of the F-22 to wartime operations from 2005 – 2014 was limited at best. In fact, its value to the wars in Iraq and Afghanistan was less than the MQ-1 Predator, an unmanned aircraft system (UAS) that was developed from an advanced concept technology demonstration (ACTD) in the mid-1990s.[12] This change in threat context drove a dramatic reduction in the planned F-22 procurement numbers, from over 700 aircraft to less than 200. This reduced buy reflected that the actual value of the F-22 for national defense problems in 2005 was much less than anticipated.

Finally, errors in valuing innovations often reflect other errors in predicting return on investment (ROI), especially with respect to disruptive innovations. In general, the returns on sustaining innovation investments are better understood and more easily quantifiable than for the relatively unknown disruptive technologies, even for the technical experts. For example, in the early years of rocket research Jerome Hunsaker, who was chairman of the National Advisory Committee for Aeronautics (NACA) until 1956, claimed that given the choice he would invest in improving windscreen de-icing fluid over rocket development.[13] His reasoning must have been that the ROI for de-icing fluid was guaranteed, while rockets still looked like fantasy. Now, with the benefit of hindsight, it is very clear that the ROI from rocket research has been greater. To the credit of leaders in the newly established United States Air Force (USAF), investments into rocket technology continued despite the perceived risks, until intercontinental ballistic missile (ICBM) capabilities were realized.

Why Sustaining Innovations Alone are Insufficient

Sustaining innovations alone are insufficient to maintain leadership in a particular industry; disruptive innovations are required. The United States military leadership needs to understand this dynamic, and develop acquisition policy that builds disruptive innovation into the future force. The adoption of disruptive innovations will benefit the United States by creating renewed technological leadership with new capabilities.[14]

Technology innovations provide military advantages along two dimensions. The first dimension is exclusivity, which is the unique ability to exploit a new technology. For example, when the United States was the only nation with nuclear weapons its exclusivity advantage was at a maximum, but as other militaries adopted nuclear weapons the exclusivity advantage declined. The second dimension of innovation advantage is the performance lead in exploitation of the technology. This lead generally results from being an early adopter of a particular innovation, thereby gaining a head start over the later adopting militaries. Although sustaining innovations incrementally increase performance within existing capabilities, advantages will inevitably decay along both dimensions of exclusivity and performance.

The loss of exclusivity occurs as technological innovations diffuse across the globe. The diffusion of innovations has been studied thoroughly, and is characterized as following an s-curve pattern.[15] This pattern, shown in figure 1, describes the dynamics of how the innovation is adopted across a population over time. It shows that the innovation spreads slowly at first among early adopters, then it accelerates to spread quickly across the majority, and finally adoption rate decelerates as the last holdouts make the change. Since exclusivity advantage is the inverse of diffusion, it decays along a z-curve pattern as seen in figure 2. When exclusivity is lost the only remaining dimension of advantage is performance.

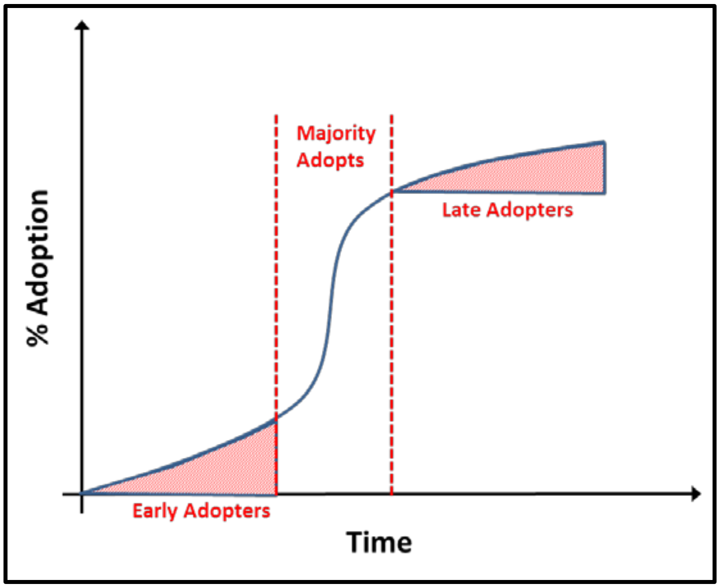

Figure 1. Diffusion of Innovation S-Curve Pattern

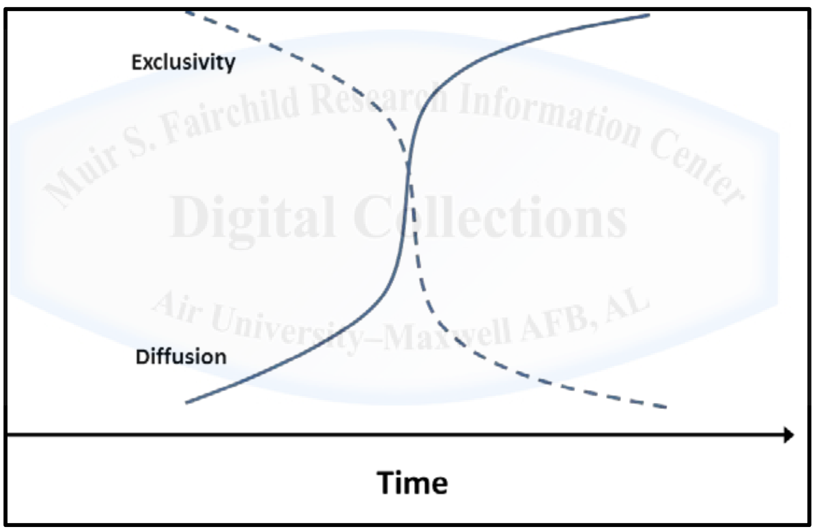

Figure 2. The Loss of Exclusivity is Inverse to Diffusion

The loss of performance lead occurs because the leader will encounter diminishing returns on investment before the trailer does. The leader has harvested the “low hanging fruit” in performance improvement, and subsequent incremental improvements become hard to find. The follower benefits from larger increments in performance for the same investment, and also learns by observing the leader. This eventually results in parity of performance for the capability.

The only way to gain or reset both the exclusivity and performance advantages is to be an early adopter of a disruptive innovation, one that leads to a completely new capability that

measures performance against new performance variables. This will effectively establish a whole new exclusivity z-curve, and give the early adopter a performance advantage.[16] Unfortunately, adopting disruptive innovations within a leading organization is difficult due to the biases encountered in its use of resources, processes, and values.[17]

The Biases against Disruptive Innovations

Dominant organizations have many biases against developing disruptive innovations that are very difficult to overcome, because they stem from good management practices.[18] One of these "good practices" is seeking customer opinion about technology development. For the defense acquisition system these customers are the operators of fielded systems. While listening to these customers is important, they tend to bias investments toward only sustaining innovations that improve along existing performance metrics.[19] Since disruptive technologies generally underperform along these old value metrics, customers tend to assign to them a low value.[20] Analysts at the Center for a New American Security (CNAS) agree stating that "… [for] dominant actors, there is lower 'marginal utility' for game-changing technology relative to weaker actors".[21]

Risk aversion is another bias since investing in disruptive innovations requires tolerance for failures. Leadership generally like sure bets, and as CNAS claims, they "… will almost always favor guaranteed additional capacity today over potential capability tomorrow".[22] Many initially promising disruptive investments fail to produce a useful technology, and they may be perceived as results of bad policy after the fact. If they don't completely fail, some may underperform expectations, especially if they were oversold by strong proponents of the innovation. This underperformance can easily occur when the disruptive innovation is integrated too early, before the technology and its intended application have had time to fully develop.[23]

Still another failure can occur when the wrong application is identified during technology readiness assessments. All of these failure modes must be tolerated, since there is an experimental aspect to finding truly disruptive innovations. If these failures aren't tolerated by leadership, the continued development of other disruptive innovation ideas will be extremely difficult to justify.

Perhaps the largest biasing factor against disruptive innovation in leading organizations is the competition with sustaining innovation for limited resources. An example occurred at the Skunk Works Division of Lockheed Martin (LM) in the early 1970s. Despite their tremendous success at developing innovative aircraft like the U-2 and SR-71, Skunk Works had many enemies on the LM board of directors, and experienced great pressure to justify their independent resources with new business.[24] When the legendary designer of the SR-71, Kelly Johnson, was presented with the idea for a stealth fighter, he claimed that resources would be better spent on continuing development of missile technology.[25] The USAF wasn't particularly interested in stealth either, and preferred sustaining investments into flying lower and faster with the development of the B-1.[26] Ultimately, it was not the big USAF customer but the niche customer, the Defense Advanced Research Projects Agency (DARPA) that developed the first stealth prototype.[27]

This brings up yet another bias within large leading organizations, namely, the initial disinterest in the niche applications served by disruptive innovations, as compared to interest in major applications served by entrenched technologies. The business version of this bias was expressed by Christensen in claiming that leading producers require large markets to satisfy their growth needs, and aren't interested in small ones where disruptive innovations initially start out.[28] The military version of this is the preference for finding solutions to the most pressing

national security needs, and less interest in solving the relatively small, or niche concerns. This was seen in the development of the UAS, when the USAF was not initially involved in the Predator ACTD.[29] Since it was originally envisioned only for niche intelligence, surveillance, and reconnaissance (ISR) missions in direct support of ground forces, the initial USAF interest in the program was low. The USAF became interested in the Predator only after it was clear that the ACTD was transitioning into an acquisition program. Much later on during the counterterrorism war in Afghanistan, the USAF became even more interested in UAS technology, supporting development of armed Predators, and transferring its fighter, bomber, and cargo pilots into flying large numbers of hellfire-armed Predators. Essentially, once the application had moved from niche to major importance, interest from the world's strongest air force increased.

The Adaptive Solution

Technological surprise is more likely to be caused by the failure to recognize an innovation's value than failure to recognize its existence. These valuation errors stem from uncertainty about the future needs, which in turn cause the failure to adapt. If the innovation is truly disruptive, the future circumstances will eventually make its true value clear to the rejecting organization, at which point it is likely too late.

The starting point for successfully navigating the landscape of disruptive innovations and recognizing their value is to understand what Christensen calls the "Principles of Disruptive Innovation" as paraphrased in military terms below:

> ***1. Military customers and investors are stronger drivers of resource decisions than are commanders.*** These customers are the warfighters, or users, and the investors are the taxpayers as represented by government command authorities.

2. Dominant militaries are more interested in solving big defense problems than small ones. Big defense problems involve applications associated with the high consequence threats, where the small problems have lower consequences of failure.

3. The unforeseen military applications for disruptive innovations cannot be easily analyzed for value potential. The applications are unforeseen because the future context and value metrics are uncertain.

4. Mature military culture, as embodied in its processes, resources, and values, hinders the development and adoption of disruptive innovations. While people are generally adaptive, organizational cultures usually are not. These cultures may have difficulty recognizing value in disruptive innovations.

5. Disruptive innovations improve and then move from their original niche applications into high-end applications. This move upmarket occurs as the technology performance improves and value metrics evolve. This makes disruptive innovations threatening to stakeholders with interests in sustaining the old technology.[30]

These principles summarize the reality of managing disruptive innovation and can guide military leaders' decisions as they seek to capitalize on new technology.

One approach that can successfully navigate this terrain and develop disruptive capabilities is to employ the Palchinsky Principles, as described by Harford in his book *Adapt*.[31] This approach is similar to a trial and error search for new capabilities, and they are summarized as: fail often due to trying new ideas, fail at a small scale, and learn from failures. Failing often implies risk tolerance, failing small mitigates risk by avoiding "gold plated mistakes", and learning salvages an intangible return from a failed idea.

Another way to navigate the disruptive innovation landscape is to spinoff a business unit that can develop the innovation to its full potential.[32] In military terms this would equate to developing independently funded organizations that develop disruptive innovations and new doctrine simultaneously. Examples of successful "spinoffs" have occurred in the military services. One example occurred in the early 20th century when the US Army formed the Air Service, then the Air Corps, and finally established the Air Corps Tactical School (ACTS) to work doctrine. Billy Mitchell advocated for this spinoff in the interwar years and was adamant that the full potential of airpower would not be attained within the greater US Army culture.[33] This independent air arm resulted in dramatic growth for airpower capabilities. Another example occurred in the creation of the United States Special Operations Command (USSOCOM) with its own acquisition authority. This allowed it to develop capabilities for the relatively small number of special operations forces (SOF), avoiding the resource competition within the larger services. Also, SOF doctrine is developed more jointly than service specific doctrine, which allows USSOCOM to value SOF specific disruptive innovations through its own value lens.

A more specific solution comes from the following five recommendations for acquisitions leaders. In some cases they are already implemented to a limited degree, and where that is true they should be increased, or at a minimum not decreased in the face of budgetary constraints. Each recommendation is listed as a direct response to one of the five principles of disruptive innovation, and a short explanation follows each recommendation. Military acquisition leaders should:

1. Develop the capabilities that customers want, but also make small investments in capabilities that existing customers aren't interested in. This requires more focus on technology push, as opposed to only requirements pull for capabilities. Customers and

investors may be correct about their near future projected needs, but are less likely to anticipate the utility in disruptive innovations. Reframe the value question for customers and investors by considering whether changes to the operational model or doctrine would increase the innovation's anticipated value.

2. Employ research and development resources to solve problems across the range of military operations. By opening the aperture of potential applications for new technologies, the probability of being an early adopter of disruptive innovation increases. Some technologies that solve problems in a low consequence operation may have greater potential in the future in high consequence operations.

3. Use trial and error to find an intermediate application where a potential disruptive innovation can achieve a quick return on investment. Avoid promising too much for an innovation and pointing to the most challenging military application as the first goal. Instead, intentionally target less challenging intermediate applications to start with, and find areas where the innovation can become value added quickly. By getting the technology into an intermediate application it will be viewed as pulling its own weight and justifying its continued development for the more challenging applications will be easier. Also, learning will occur with user feedback.

4. Create organizations with an independent culture and independent funds to develop disruptive innovations. Protect these innovative climates from intrusion by the greater service cultural biases. Incentivize within these organizations based on creativity and don't punish idea failures. Small failures are necessary for discovery.

5. Raise awareness of changing value metrics across the defense enterprise and scan for disruptive threats and opportunities. Educate the force about uncertainty in future value

metrics, and its relationship to finding and exploiting disruptive innovations. Use the evolving value metrics to revisit technologies that found intermediate niche applications and determine if they have progressed enough to solve higher consequence problems.

Finally, it is important to state that the investment balance between disruptive and sustaining innovations should not become an either/or proposition. Investments into sustaining innovations must continue while the next disruptive innovation is sought. Improvement to capabilities in support of current doctrine acts as a buffer to rising threats, and allows commanders to hold disruptive technological surprise in reserve if desired. Keeping this proper balance of investment for developing both sustaining and disruptive innovations is the key to successful adaptive acquisitions.

Conclusion

Military acquisitions leaders must effectively develop innovative technology to maintain global dominance in the land, sea, air, space, and cyberspace domains. Investments into new technologies that only sustain capabilities of current doctrine are insufficient to maintain the edge over adversaries. Diminishing returns and loss of exclusive use of these sustaining innovations make the leader's loss of advantage inevitable. Therefore, new technologies that dramatically modify operations and significantly change the metrics of value are required. These are the disruptive innovations that will gain and maintain global advantage.

There are many tensions that arise in the efforts to develop these disruptive innovations. Bureaucracies generally don't like to be "disrupted", especially when their way of doing business has worked well in the past. This creates a strong bias toward expending limited research and development resources toward the development of only sustaining innovations, which alone are insufficient. There is also difficulty in justifying disruptive investments, since the actual value of

the innovation is difficult, if not impossible, to determine *a priori*. In fact, most of the claimed potential disruptive technologies will not pan out, and the ones that do may under-deliver during their early adoption periods. Customers may not care for the innovation and its potential may not be fully realized if it is only integrated in support of old operational models. New doctrine built around the technology's potential will be required to realize the full value of disruptive innovations, and new warfighter groups that employ the disruptive capabilities will be required to advocate for both the new technology and the new doctrine.

An advantage for emerging military powers is that they don't face these same biases against disruptive innovations. Like Germany in the interwar years between WWI and WWII, they are building a force on the latest technology available, and their lack of entrenched doctrines and organizational cultures leave them open to more possibilities. Recognizing this, leaders within dominant legacy militaries must avoid the tendency to underestimate the risk of emerging threats, an error that is caused by the very same biases that lead them to reject disruptive innovations.

The way ahead for military acquisitions leaders is to balance investments between those developments that improve performance along old value metrics, and those that create whole new value paradigms. Investing in sustaining innovations will buffer against the loss of capability advantage, but new disruptive capabilities are absolutely required to remain continuously dominant. This can be accomplished by implementing these five recommendations:

1. Develop the capabilities that customers want, but also make small investments in capabilities that existing customers aren't interested in.

2. Employ research and development resources to solve problems across the range of military operations.

3. Use trial and error to find an intermediate application where a potential disruptive innovation can achieve a quick return on investment.

4. Create organizations with an independent culture and independent funds to develop disruptive innovations.

5. Raise awareness of changing value metrics across the defense enterprise and scan for disruptive threats and opportunities.

Implementation of these recommendations will require an adaptive mindset, a culture of innovation that doesn't get threatened by change. A culture that embodies Harford's "Palchinsky Principles" of comfort with experimental failure, failure on small scales, and learning from those failures.[34]

Notes

(All notes appear in shortened form. For full details, see the appropriate entry in the bibliography.)

1. Boot, War Made New, 215.
2. Boot, War Made New, 217-220.
3. Christensen, *The Innovator's Dilemma*, xvi.
4. Clayton M. Christensen (Kim B. Clark Professor of Business Administration at the Harvard Business School), interview by the author, 19 February 2014.
5. Christensen, *The Innovator's Dilemma*, xvii – xviii.
6. Bottelson, "Requirements and Cost Stability," *Defense Acquisition Research Journal*, October 2011, 393.
7. Rich and Janos, *Skunk Works*, 21-22.
8. Clayton M. Christensen (Kim B. Clark Professor of Business Administration at the Harvard Business School), interview by the author, 19 February 2014.
9. Christensen, *The Innovator's Dilemma*, 101-107.
10. Clayton M. Christensen (Kim B. Clark Professor of Business Administration at the Harvard Business School), interview by the author, 19 February 2014.
11. Clayton M. Christensen (Kim B. Clark Professor of Business Administration at the Harvard Business School), interview by the author, 19 February 2014.
12. Thirtle, Johnson, and Birkler, *The Predator ACTD*, 1-2.
13. Hallion, "Air and Space Power," *A History of Air Warfare*, 375.
14. Christensen, *The Innovator's Dilemma*, 46-47.

15. Rogers, *Diffusion of Innovations*, 10-11.
16. Christensen, *The Innovator's Dilemma*, 47.
17. Christensen, The Innovator's Dilemma, 186-191.
18. Christensen, The Innovator's Dilemma, xv.
19. Christensen, *The Innovator's Dilemma*, xx.
20. Christensen, *The innovator's Dilemma*, xviii.
21. Brimley et al., *Game Changers*, 11.
22. Brimley et al., *Game Changers*, 22.
23. Brimley et al., *Game Changers*, 13.
24. Rich, *Skunk Works*, 13.
25. Rich, *Skunk Works*, 25.
26. Rich, *Skunk Works*, 18.
27. Rich, *Skunk Works*, 23-25.
28. Christensen, *The Innovator's Dilemma*, xxiii-xxviii.
29. Thirtle, Johnson, and Birkler, *The Predator ACTD*, 55-58.
30. Christensen, *The Innovator's Dilemma*, xxiii-xxviii.
31. Harford, *Adapt*, 27.
32. Christensen, *The Innovator's Dilemma*, 202-207.
33. Mitchell, *Winged Defense*, 215.
34. Harford, *Adapt*, 27.

Bibliography

Boot, Max. *War Made New: Technology, Warfare, and The Course of History, 1500 to Today.* New York, NY: Gotham Books, 2006.

Bottelson, Jay D. "Requirements and Cost Stability: A Case Study of the F/A-18 Hornet Program." *Defense Acquisition Research Journal* (Defense Acquisition University), no. 60 (October 2011): 388-403.

Brimley, Shawn, Ben FitzGerald, Kelley Sayler, and Peter W. Singer. *Game Changers: Disruptive Technology and U.S. Defense Strategy.* Washington DC: Center for a New American Security, 2013.

Browning, Peter. *The Changing Nature of Warfare: The Development of Land Warfare From 1792 to 1945.* Cambridge: Cambridge University Press, 2002.

Christensen, Clayton M. *The Innovator's Dilemma: The Revolutionary National Bestseller That Changed The Way We Do Business.* New York, NY: HarperBusiness, 2000.

Clarke, Richard A., and Robert K. Knake. *Cyber War: The Next Threat to National Security and What to do About it.* New York, NY: ecco - HarperCollins, 2010.

Constable, Pam. "Surrounded by Russian militiamen, a Ukrainian officer says his outpost is cut off." *www.washingtonpost.com.* March 10, 2014. http://www.washingtonpost.com/world/europe/surrounded-by-russian-militiamen-a-ukrainian-officer-says-his-outpost-is-cut-off/2014/03/10/beb1b5fe-a884-11e3-8d62-419db477a0e6_story.html (accessed March 17, 2014).

Converse III, Elliott V. *History of Acquisition in the Department of Defense.* Vol. 1, *Rearming for the Cold War 1945-1960*, edited by Glen R. Asner. Washington DC: Office of the Secretary of Defense, 2012.

Hallion, Richard P. "Air and Space Power: Climbing and Accelerating." In *A History of Air Warfare*, edited by John Andreas Olsen, 371-393. Washington DC: Potomac Books, 2010.

Harford, Tim. *Adapt: Why Success Always Starts with Failure.* New York, NY: Picador, 2011.

Lorber, Azriel. *Misguided Weapons: Technological Failure and Surprise on the Battlefield.* Washington, DC: Potomac Books, 2002.

Mitchell, William. *Winged Defense: The Development and Possibilities of Modern Air Power - Economic and Military*. 1925. Reprint, Tuscaloosa, AL: The University of Alabama Press, 2009.

Rich, Ben R., and Leo Janos. *Skunk Works: A Personal Memoir of My Years at Lockheed.* New York, NY: Little, Brown and Company, 1994.

Rogers, Everett M. *Diffusion of Innovations.* 5th ed. New York, NY: Free Press, 2003.

Singer, P.W. *Wired for War: The Robotics Revolution and Conflict in the Twenty-first Century*. New York, NY: Penguin Books, 2009.

Thirtle, Michael R., Robert V. Johnson, and John L. Birkler. *The Predator ACTD: A Case Study for Transition Planning to the Formal Acquisition Process.* Santa Monica, CA: RAND, 1997.